Turbocharger System Requirements
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-1
Name: 1.0 General System Requirements
Requirement type: Not applicable
ASIL level: Not applicable
Modified Date: 12/21/2023
Verification criteria: Not applicable
Verification method: Not applicable
Current version: 1
Type: Header
Variant: All
Domain: Propulsion System
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-2
Name: Product Variants Overview
Requirement type: Not applicable
ASIL level: Not applicable
Modified Date: 12/21/2023
Verification criteria: The document shall list the defined variants for the project.
Verification method: Review
Current version: 2
Type: Information
Variant: All
Domain: Propulsion System
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-3
Name: The turbocharger system shall provide boosted air pressure to the engine intake manifold.
Requirement type: Functional
ASIL level: QM
Modified Date: 12/21/2023
Verification criteria: Boost pressure is greater than atmospheric pressure under specified engine load conditions.
Verification method: Test
Current version: 3
Type: Requirement
Variant: All
Domain: Propulsion System
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-4
Name: The system shall operate in all vehicle operating modes.
Requirement type: Functional

ASIL level: QM
Modified Date: 12/21/2023
Verification criteria: The turbocharger functionality is verified during engine start-up, normal operation, and shutdown test cases.
Verification method: Test
Current version: 1
Type: Requirement
Variant: All
Domain: Propulsion System
Status: in review
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-5
Name: 2.0 Performance Requirements
Requirement type: Not applicable
ASIL level: Not applicable
Modified Date: 12/21/2023
Verification criteria: Not applicable
Verification method: Not applicable
Current version: 1
Type: Header
Variant: All
Domain: Propulsion System
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-6
Name: The system shall achieve a target boost pressure of 1.2 bar (gauge) at 3000 RPM engine speed and 80% load.
Requirement type: Performance
ASIL level: ASIL B
Modified Date: 12/21/2023
Verification criteria: On a test bench, with engine conditions set to 3000 RPM and 80% load, the boost pressure measured at the intake manifold shall be 1.2 bar +/- 0.05 bar.
Verification method: Test
Current version: 4
Type: Requirement
Variant: Gasoline_1.5L
Domain: Propulsion System
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-7
Name: The system shall achieve a target boost pressure of 1.5 bar (gauge) at 2500 RPM engine speed and 80% load.
Requirement type: Performance
ASIL level: ASIL B
Modified Date: 12/21/2023
Verification criteria: On a test bench, with engine conditions set to 2500 RPM and 80% load, the boost pressure measured at the intake manifold shall be 1.5 bar +/-

0.05 bar.
Verification method: Test
Current version: 3
Type: Requirement
Variant: Diesel_2.0L
Domain: Propulsion System
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-8
Name: The turbocharger transient response shall be fast.
Requirement type: Performance
ASIL level: QM
Modified Date: 12/21/2023
Verification criteria: The performance should feel responsive to the driver. (Issue: Vague/Untestable)
Verification method: Demonstration
Current version: 1
Type: Requirement
Variant: All
Domain: Propulsion System
Status: draft
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-9
Name: The system shall reach 90% of target boost pressure within 350ms from a 20% to 80% accelerator pedal step.
Requirement type: Performance
ASIL level: QM
Modified Date: 12/21/2023
Verification criteria: Time to reach 90% target boost is measured during a pedal step transient test on a dyno. The time shall be <= 350ms.
Verification method: Review (Issue: Incorrect method, should be Test)
Current version: 2
Type: Requirement
Variant: Gasoline_1.5L, HighPerformance_V6
Domain: Propulsion System
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-10
Name: Compressor efficiency shall be maximized in the primary operating range.
Requirement type: Performance
ASIL level: QM
Modified Date: 12/21/2023
Verification criteria: The operating points on the compressor map should be in a region of high efficiency.
Verification method: Analysis
Current version: 1
Type: Requirement
Variant: All

Domain: Propulsion System
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-11
Name: 3.0 Thermal Management
Requirement type: Not applicable
ASIL level: Not applicable
Modified Date: 12/21/2023
Verification criteria: Not applicable
Verification method: Not applicable
Current version: 1
Type: Header
Variant: All
Domain: Propulsion System
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-12
Name: The turbocharger shall operate within a coolant temperature range of -40°C to 120°C.
Requirement type: Environmental
ASIL level: QM
Modified Date: 12/21/2023
Verification criteria: The system is tested in a thermal chamber from -40°C to 120°C and must remain functional.
Verification method: Test
Current version: 2
Type: Requirement
Variant: All
Domain: Propulsion System
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-13
Name: The turbine housing surface temperature shall not exceed 950°C during peak load conditions.
Requirement type: Safety
ASIL level: ASIL B
Modified Date: 12/21/2023
Verification criteria: Temperature measured at the specified location on the turbine housing does not exceed 950°C during the max power test case.
Verification method: Test
Current version: 3
Type: Requirement
Variant: All
Domain: Propulsion System
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-14

Name: The bearing housing temperature must remain within an acceptable range.
Requirement type: Performance
ASIL level: QM
Modified Date: 12/21/2023
Verification criteria: The temperature is checked and is okay. (Issue: Vague/Untestable)
Verification method: Test
Current version: 1
Type: Requirement
Variant: All
Domain: Propulsion System
Status: rejected
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-15
Name: The turbocharger coolant circuit flow rate shall be at least 5 liters/minute when the coolant pump is active.
Requirement type: Performance
ASIL level: QM
Modified Date: 12/21/2023
Verification criteria: Measure the coolant flow rate on a test bench with the pump at 100% duty cycle. The flow shall be >= 5 L/min.
Verification method: Test
Current version: 1
Type: Requirement
Variant: All
Domain: Propulsion System
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-16
Name: 4.0 Actuator Control
Requirement type: Not applicable
ASIL level: Not applicable
Modified Date: 12/21/2023
Verification criteria: Not applicable
Verification method: Not applicable
Current version: 1
Type: Header
Variant: All
Domain: Powertrain Control
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-17
Name: The wastegate actuator shall control its position as commanded by the Engine Control Unit (ECU).
Requirement type: Functional
ASIL level: ASIL C
Modified Date: 12/21/2023
Verification criteria: The actuator position reported via CAN shall match the

commanded position from the ECU within a specified tolerance.
Verification method: Test
Current version: 4
Type: Requirement
Variant: All
Domain: Powertrain Control
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-18
Name: The wastegate actuator position accuracy shall be within +/- 2% of its full range.
Requirement type: Performance
ASIL level: QM (Issue: Likely incorrect ASIL, control accuracy is safety-relevant)
Modified Date: 12/21/2023
Verification criteria: Actuator is commanded to move to 10%, 50%, and 90% of its range. The measured position must be within +/- 2% of the command.
Verification method: Test
Current version: 2
Type: Requirement
Variant: All
Domain: Powertrain Control
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-19
Name: The actuator shall move from 10% to 90% open position in less than 150ms.
Requirement type: Performance
ASIL level: QM
Modified Date: 12/21/2023
Verification criteria: Time to travel from 10% to 90% is measured with an oscilloscope. Time shall be < 150ms.
Verification method: Test
Current version: 1
Type: Requirement
Variant: Gasoline_1.5L, HighPerformance_V6
Domain: Powertrain Control
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-20
Name: The actuator shall hold its position with a 0% command deviation under maximum exhaust backpressure conditions.
Requirement type: Performance
ASIL level: ASIL B
Modified Date: 12/21/2023
Verification criteria: TBD (Issue: Incomplete)
Verification method: Test
Current version: 1
Type: Requirement
Variant: All

Domain: Powertrain Control
Status: draft
... (Requirements 21-40: Further Actuator and Control Logic) ...
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-41
Name: 5.0 Sensors
Requirement type: Not applicable
ASIL level: Not applicable
Modified Date: 12/21/2023
Verification criteria: Not applicable
Verification method: Not applicable
Current version: 1
Type: Header
Variant: All
Domain: Propulsion System
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-42
Name: The system shall include a turbine speed sensor.
Requirement type: Functional
ASIL level: ASIL B
Modified Date: 12/21/2023
Verification criteria: Presence of the turbine speed sensor is confirmed.
Verification method: Inspection
Current version: 2
Type: Requirement
Variant: All
Domain: Propulsion System
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-43
Name: The turbine speed sensor shall measure rotational speeds up to 280,000 RPM.
Requirement type: Performance
ASIL level: ASIL B
Modified Date: 12/21/2023
Verification criteria: Using a signal generator to simulate sensor input, verify that the reported speed is accurate up to 280,000 RPM.
Verification method: Test
Current version: 2
Type: Requirement
Variant: All
Domain: Propulsion System
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-44
Name: The turbine speed sensor accuracy shall be +/- 1%.
Requirement type: Performance

ASIL level: ASIL B
Modified Date: 12/21/2023
Verification criteria: The sensor shall report a temperature of 25°C +/- 2°C when at ambient room temperature. (Issue: Mismatched verification criteria)
Verification method: Test
Current version: 1
Type: Requirement
Variant: All
Domain: Propulsion System
Status: in review
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-45
Name: The system shall include a compressor outlet temperature sensor.
Requirement type: Functional
ASIL level: QM
Modified Date: 12/21/2023
Verification criteria: The presence of the temperature sensor is confirmed by reviewing the design.
Verification method: Review
Current version: 1
Type: Requirement
Variant: All
Domain: Propulsion System
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-46
Name: The compressor outlet temperature sensor shall be accurate to +/- 3°C across its operating range.
Requirement type: Performance
ASIL level: QM
Modified Date: 12/21/2023
Verification criteria: The sensor's reported temperature is compared against a calibrated reference thermocouple at -40°C, 25°C, and 150°C. The error must not exceed 3°C.
Verification method: Test
Current version: 3
Type: Requirement
Variant: All
Domain: Propulsion System
Status: approved
... (Requirements 47-60: Further Sensor and Electrical Interface Requirements) ...
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-61
Name: 6.0 Diagnostics and Fault Handling
Requirement type: Not applicable
ASIL level: Not applicable
Modified Date: 12/21/2023
Verification criteria: Not applicable

Verification method: Not applicable
Current version: 1
Type: Header
Variant: All
Domain: Powertrain Control
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-62
Name: The system shall detect an actuator-stuck fault.
Requirement type: Diagnostic
ASIL level: ASIL B
Modified Date: 12/21/2023
Verification criteria: If the actuator position does not change after a new position is commanded for >500ms, a fault is registered.
Verification method: Test
Current version: 2
Type: Requirement
Variant: All
Domain: Powertrain Control
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-63
Name: The system shall set a Diagnostic Trouble Code (DTC) P0234 for an over-boost condition.
Requirement type: Diagnostic
ASIL level: QM
Modified Date: 12/21/2023
Verification criteria: When an over-boost condition is induced on the test bench, verify that DTC P0234 is set and can be read by a diagnostic tool.
Verification method: Test
Current version: 1
Type: Requirement
Variant: All
Domain: Powertrain Control
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-64
Name: The system shall detect a turbine speed sensor failure (short/open circuit).
Requirement type: Diagnostic
ASIL level: ASIL D (Issue: ASIL level is likely too high for this type of diagnostic)
Modified Date: 12/21/2023
Verification criteria: The speed sensor signal wire is disconnected, and a corresponding DTC is set within 1 second.
Verification method: Test
Current version: 1
Type: Requirement
Variant: All

Domain: Powertrain Control
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-65
Name: Upon detecting a critical fault, the system should enter a safe state.
Requirement type: Safety
ASIL level: ASIL C
Modified Date: 12/21/2023
Verification criteria: For each defined critical fault, verify the system commands the wastegate to the fully open position to minimize boost.
Verification method: Test
Current version: 3
Type: Requirement
Variant: All
Domain: Powertrain Control
Status: approved
... (Requirements 66-75: Further Diagnostic Requirements) ...
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-76
Name: 7.0 Durability and Environmental
Requirement type: Not applicable
ASIL level: Not applicable
Modified Date: 12/21/2023
Verification criteria: Not applicable
Verification method: Not applicable
Current version: 1
Type: Header
Variant: All
Domain: Propulsion System
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-77
Name: The turbocharger assembly shall have a service life of 250,000 km or 10 years.
Requirement type: Durability
ASIL level: Not applicable
Modified Date: 12/21/2023
Verification criteria: The turbocharger must pass the 1000-hour endurance test cycle without functional degradation.
Verification method: Analysis (Issue: Incorrect method, should be Test)
Current version: 2
Type: Requirement
Variant: All
Domain: Propulsion System
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-78

Name: The actuator electronics housing shall meet IP6k7 rating for dust and water ingress protection.
Requirement type: Environmental
ASIL level: QM
Modified Date: 12/21/2023
Verification criteria: The housing passes the dust chamber test and water immersion test as defined in ISO 20653.
Verification method: Test
Current version: 1
Type: Requirement
Variant: All
Domain: Propulsion System
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-79
Name: The system shall withstand mechanical vibrations as specified in document [VIB-PROFILE-001].
Requirement type: Environmental
ASIL level: QM
Modified Date: 12/21/2023
Verification criteria: The system remains fully functional after being subjected to the vibration profile specified in VIB-PROFILE-001 on a shaker table.
Verification method: Test
Current version: 1
Type: Requirement
Variant: All
Domain: Propulsion System
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-80
Name: The system shall survive thermal shock testing.
Requirement type: Environmental
ASIL level: Not applicable
Modified Date: 12/21/2023
Verification criteria: The component passes the test. (Issue: Vague/Untestable, no reference to a standard)
Verification method: Test
Current version: 1
Type: Requirement
Variant: All
Domain: Propulsion System
Status: draft
... (Requirements 81-90: Further Durability and Communication Requirements) ...
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-91
Name: 8.0 Safety Requirements
Requirement type: Not applicable
ASIL level: Not applicable

Modified Date: 12/21/2023
Verification criteria: Not applicable
Verification method: Not applicable
Current version: 1
Type: Header
Variant: All
Domain: Propulsion System
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-92
Name: Turbine Overspeed Protection
Requirement type: Not applicable
ASIL level: Not applicable
Modified Date: 12/21/2023
Verification criteria: Safety goal is to prevent mechanical failure due to turbine overspeed.
Verification method: Not applicable
Current version: 1
Type: Information
Variant: All
Domain: Safety
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-93
Name: The system shall prevent the turbine speed from exceeding 280,000 RPM.
Requirement type: Safety
ASIL level: Not applicable (Issue: Major error, a critical safety requirement has no ASIL rating)
Modified Date: 12/21/2023
Verification criteria: During a test where conditions would cause an overspeed, verify that the control system intervenes to limit turbine speed to < 280,000 RPM.
Verification method: Test
Current version: 2
Type: Requirement
Variant: All
Domain: Safety
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-94
Name: The overspeed protection function shall have a fault tolerant time interval (FTTI) of 500ms.
Requirement type: Safety
ASIL level: ASIL C
Modified Date: 12/21/2023
Verification criteria: It is proven by analysis that the system can detect and react to an overspeed condition within 500ms.
Verification method: Analysis
Current version: 1

Type: Requirement
Variant: All
Domain: Safety
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-95
Name: The system shall limit boost pressure to a maximum of 1.8 bar (gauge) to prevent engine damage.
Requirement type: Safety
ASIL level: ASIL C
Modified Date: 12/21/2023
Verification criteria: When commanding maximum boost, the measured pressure at the intake manifold must not exceed 1.8 bar.
Verification method: Test
Current version: 3
Type: Requirement
Variant: All
Domain: Safety
Status: approved
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-96
Name: The over-boost protection mechanism is a safety feature.
Requirement type: Informational (Issue: Mismatched type, this is labeled as a requirement but is info)
ASIL level: Not applicable
Modified Date: 12/21/2023
Verification criteria: The design documentation mentions over-boost protection.
Verification method: Review
Current version: 1
Type: Requirement
Variant: All
Domain: Safety
Status: draft
... (Requirements 97-99: Further Safety and Redundancy) ...
Item Type: [Turbo] System Requirements
Locked: false
ID: TURBO-SYS-100
Name: The system shall not have any sharp edges on the exterior housing.
Requirement type: Physical
ASIL level: Not applicable
Modified Date: 12/21/2023
Verification criteria: The housing is inspected for sharp edges that could harm a service technician.
Verification method: Inspection
Current version: 1
Type: Requirement
Variant: All
Domain: Mechanical
Status: approved